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2nd Post Combustion Capture Conference (PCCC2)

Vapor-Liquid Equilibrium of CO₂ with Aqueous Solutions of DEEA, MAPA and their Mixture

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1. Introduction

Amine scrubbing is considered as one of the most competitive technologies available today to capture CO₂ from power plant flue gases. It is also well known that this technology is relatively energy intensive. Besides technological improvement in the capture process, there is a need to develop new energy efficient solvent systems. Various amine solvent systems have been studied in the open literature e.g. single amines (primary, secondary and tertiary), amine blends (tertiary amine blended with primary or secondary amines as a promoter) and sterically hindered amines both as single amines and blended with other amines or piperazine among others. There is still a need for better solvent systems with low regeneration heat requirement in the stripper by improving the equilibrium temperature sensitivity in order to reduce the need for stripping steam [1].

A new generation of mixed amine solvent systems has recently received attention which can form two liquid phases e.g. the DMXTM process [2] and the thermomorphic biphasic solvents (TBS) systems [3]. In the DMXTM process, the solvents form two immiscible phases after CO₂ absorption and only the CO₂ rich phase is sent to stripper for regeneration while the CO₂ lean phase is sent back to the absorber without regeneration. This process has claimed to reduce the reboiler duty down to 2.1 GJ/ ton CO₂ compared to 3.7 GJ/ ton CO₂ for the 30% MEA process. On the other hand, the TBS systems absorbed CO₂ and give liquid-liquid split during regeneration at relatively lower temperature of 80°C compared to the regeneration temperature of conventional alkanolamine solutions (~120°C). The main advantage of this system is lower regeneration temperature which can be achieved without the use of steam. In this work a blend of amines, 2-(diethylamino)ethanol (DEEA) and 3-(methylamino)propylamine (MAPA), is under investigations which form two liquid phases upon CO₂ absorption.

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Vapor-liquid equilibrium (VLE) of CO₂ with these aqueous amine solutions is essential for designing and modeling of unit operations in the capture process. The present work presents VLE of CO₂ in these amine solutions, both single amines and their blend.

2. Experimental/ Results

Equilibrium cells are generally used for the measurement of VLE of CO₂ in aqueous amine solutions and extensive data are available in the literature using this method. This work presents experimental measurement of solubility of CO₂ in aqueous amine solutions using a calorimeter which is generally used for the measurements of heat of absorption. Using this method one can measure both heat of absorption and CO₂ equilibrium solubility in aqueous amine solutions at the same time. Heat of absorption measurements using this setup for DEEA, MAPA and their mixture has been presented earlier [4]. The calorimeter (model CPA 122 from ChemiSens AB, Sweden) used in this work was described by Kim and Svendsen [5]. Sample solutions were fed to the reactor and CO₂ was injected to the reactor in several small steps until the solution is fully loaded with CO₂ at a given total pressure (6 bar in this work) in the reactor. The system continuously logged all the necessary parameters (reactor temperature and pressure, CO₂ storage cylinders pressure etc.) as a function of time. The CO₂ added in each feeding interval was calculated using the Peng-Robinson equation of state. The measurements were performed at temperature ranging from 40 to 120°C.

The equilibrium solubility of CO₂ were measured in 5M DEEA, 2M MAPA and their mixture 5M DEEA + 2M MAPA at a typical temperature range from 40 to 120°C used in the absorption-desorption capture process. The results for 5M DEEA are presented in Figure 1 and compared with the literature data [6]. There is good agreement between the two sets of data measured from the calorimeter (this work) and vapor-liquid equilibrium cells [6].

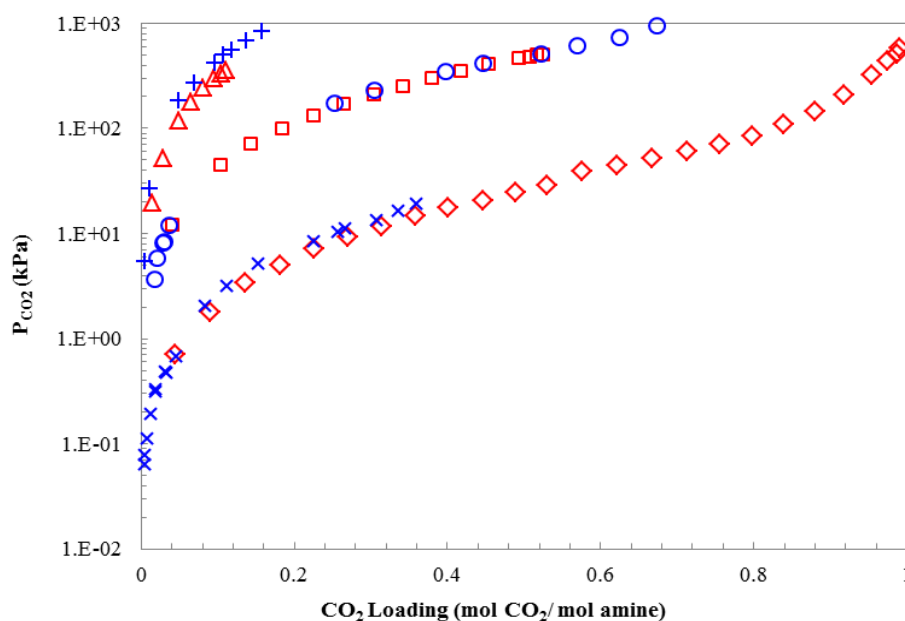


Figure 1: VLE of CO₂ with 5M DEEA at 40, 80 and 120°C. This work: \diamond , 40°C; \square , 80°C and \triangle , 120°C. Monteiro et al. [6]: \times , 40°C; \circ , 80°C and $+$, 120°C.

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